Microwave Scan Bias

Status Report

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Background

Observations

- Substantial scan bias
- Scan bias is asymmetric
- Magnitude and asymmetry is location dependent

Status until now

- No sidelobe corrections applied in L1b so far
- L1b data slots exist for Ta and Tb (= Ta + sidelobe correction)
- Interim solution: Microwave tuning applied at L2 (pre-processing)

Ongoing effort

- Characterize the scan bias
- Develop sidelobe corrections to be applied at L1b
  - Remove scan bias
  - Allow estimates of local scene Tb from measured Ta

NOAA Method

1. Compute antenna efficiencies

Integral of antenna func. over solid angles:

- Earth
- Cold Space
- Spacecraft

- **2. Estimate effective measured antenna temperature**
  - $Ta \approx fe \cdot Te + fc \cdot Tc + fs \cdot Ts$
- **3. Solve for scene brightness temperature**
  - $Tb \approx Te = (Ta - fc \cdot Tc - fs \cdot Ts) / fe$

Assumptions

a. All regions have azimuthal symmetry
b. Spacecraft covers entire backside half-sphere
c. fs is negligibly small -> See next slide!
d. Te is uniform over entire Earth view

NOAA Method - cont.

Assumption of negligible contribution from spacecraft

- Based on computations by Aerojet:
  - Source in antenna near field reduces effective antenna efficiency by more than 10
  - Spacecraft is in near field
  - Radiation emitted and reflected by Spacecraft can be ignored (<< 0.1 K)

Results

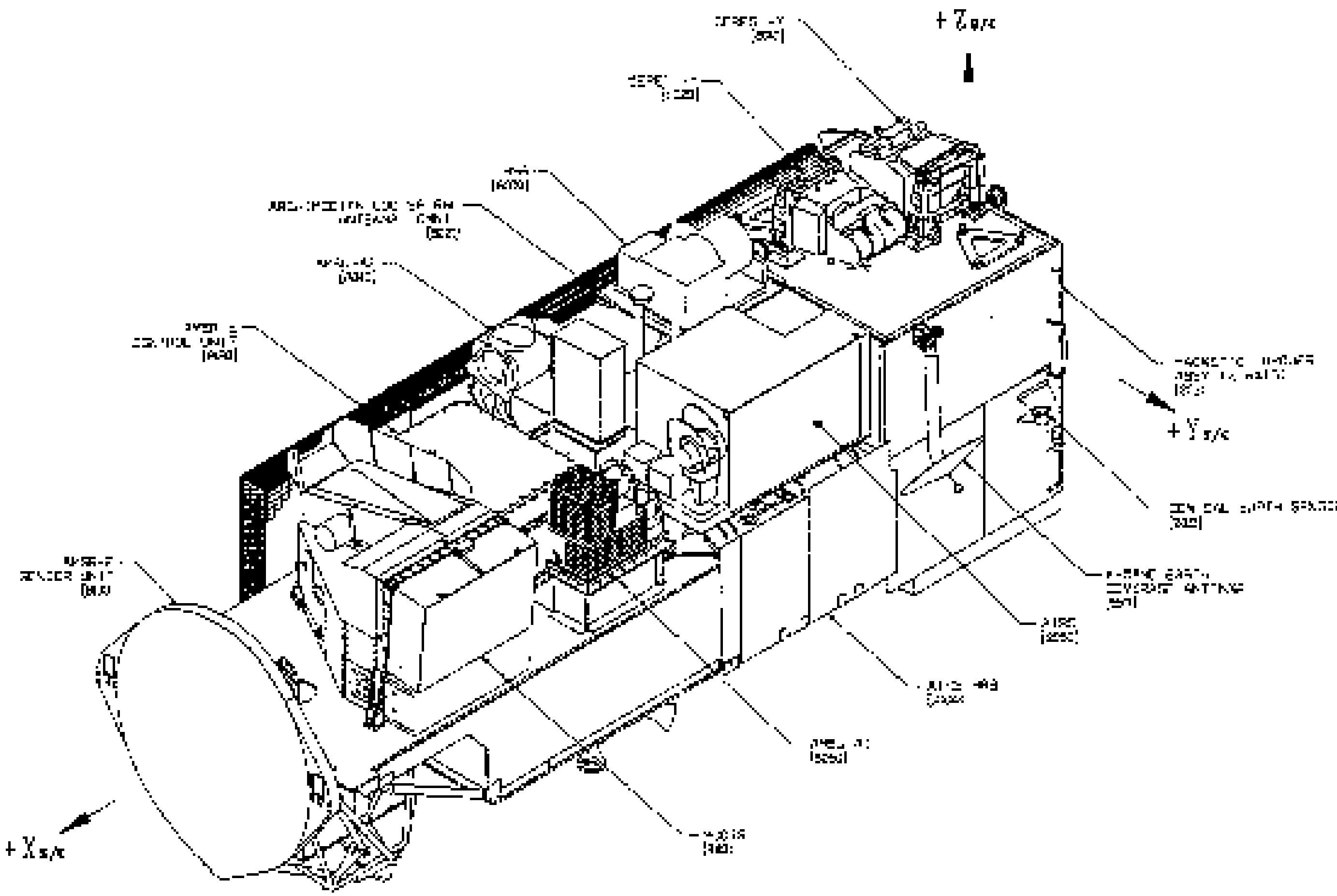
- Assumed radiometric field is azimuthally symmetric
- Therefore, any computed scan asymmetry is entirely due to asymmetric antenna function
- Computed asymmetry is then very small (fraction of 1 K)
- *This may not account for observed asymmetries*

Our Approach

- **Take into account actual S/C configuration**
  - Azimuthal-symmetry assumption is invalid
  - Spacecraft does not cover entire half-sphere
  - Space solid angle is larger than assumed - and asymmetric
  - Predicted effect: Negative bias on “space” side of scan

- **Re-examine Aerojet’s model of spacecraft radiation**
  - Reduced contribution may not apply to reflected radiation
  - Predicted effect: Variable bias on “spacecraft” side of scan

Spacecraft Configuration



Effects of S/C Configuration

AMSU-A1

- Positioned at +y edge of S/C - corresponds to right side of scan
- Sees space in ~1/4-1/2 of backside half-sphere
    - Leads to cold bias at right swath edge
- Sees S/C in other 3/4-1/2 of half-sphere (causes bias if Aerojet is wrong)
    - Leads to cold bias where cold space is reflected
    - Leads to variable bias where off-boresight Earth radiation is reflected

AMSU-A2

- Positioned at -y edge of S/C - corresponds to left side of scan
- Sees space in ~1/2-1/8 of backside half-sphere
    - Modulated by Solar Array
    - Leads to variable cold bias at left swath edge
- Sees S/C in other part of half-sphere
    - Leads to scene dependent and latitude dependent bias at right swath edge

HSB

- Positioned near -y edge, but sees mostly S/C (not space)
    - Leads to variable bias from SA reflections (left side of scan)
    - Leads to smaller cold bias from structural reflections (right side of scan)

Proposed Algorithm

Measured antenna temperature is

$$Ta = fe \cdot Tb + fc \cdot Tc + \eta \cdot fs \cdot Ts$$

where

The first term represents Earth radiation

fe is computed from antenna patterns

Tb is the (unknown) scene brightness temp. - assumed uniform across Earth

The second term represents direct space radiation

fc is computed from antenna patterns over actual space solid angles

Tc is space brightness (3.9 K for AMSU ch. 8)

The third term represents Earth and space radiation reflected from the S/C

fs is computed from antenna patterns over actual S/C solid angles

Ts is the effective reflected radiation - initially, Te = Tb or Tc

η is the effective S/C reflectivity - assumed the same for all channels

Solve equation for Tb

We will use channel-8 Obs-Calc to determine best value for η

Scan Bias Estimate

Approximation:

Ta = Obs; Tb = Calc; $\Delta T = Ta - Tb$ (bias)

$$\Delta T = Ta - (Ta - fc \bullet Tc - \eta \bullet fs \bullet Ts)/fe$$

$$\boxed{\Delta T \approx - fc \bullet Ta - fsc \bullet Ta - fse \bullet (Ta - \eta Te)}$$ (note: $fe+fc+fs=1$)

where

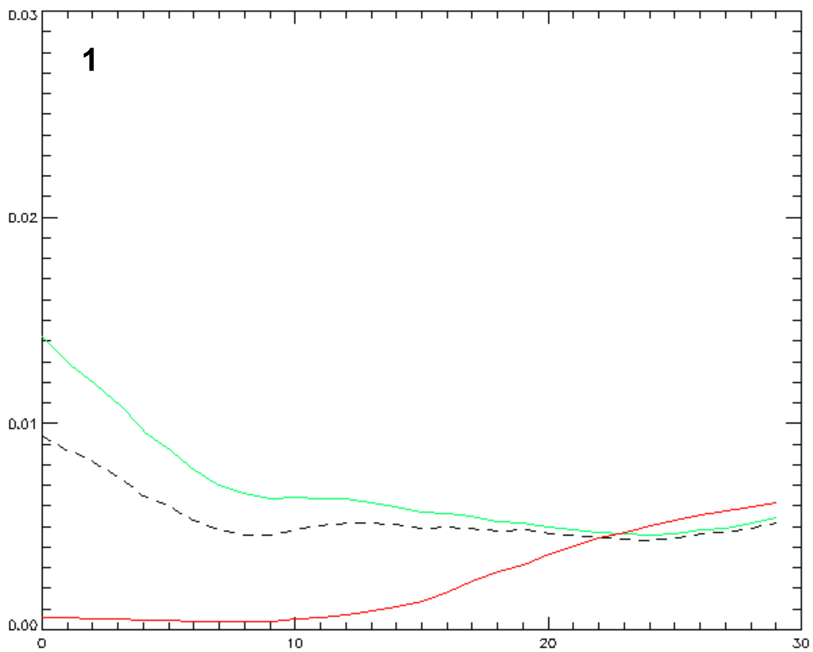
the first term represents bias due to direct space radiation
the second term represents bias due to space radiation reflected from the S/C
the third term represents bias due to reflected off-boresight Earth radiation

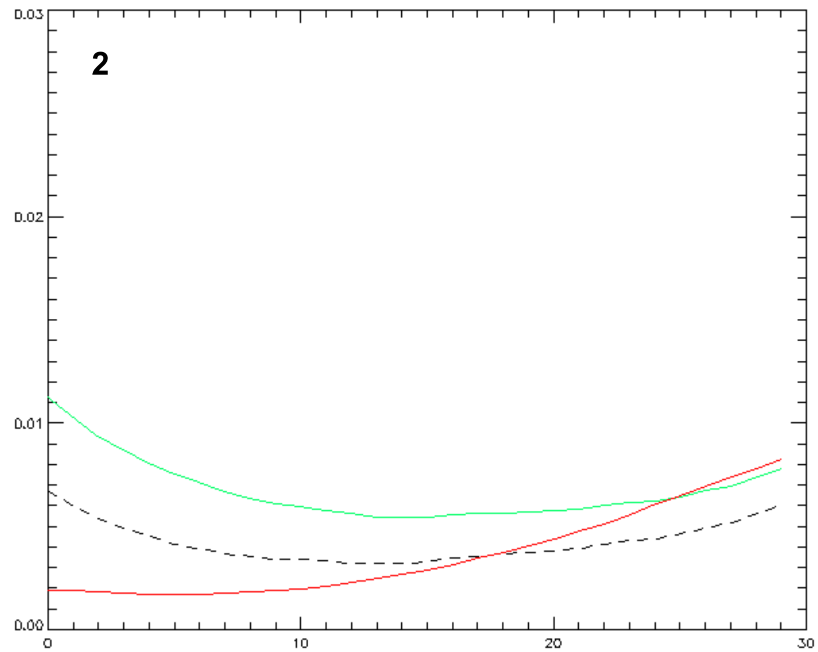
Approximation is based on $fe \approx 1$; $fc, fs \ll 1$; $Tc \ll Ta$

Positive bias can occur only if $\eta Te > Ta$ e.g., in window channels)

In the polar regions it may be possible to have reflected solar radiation contribute to the third term, resulting in a positive bias

Efficiencies: Ch. 1-2

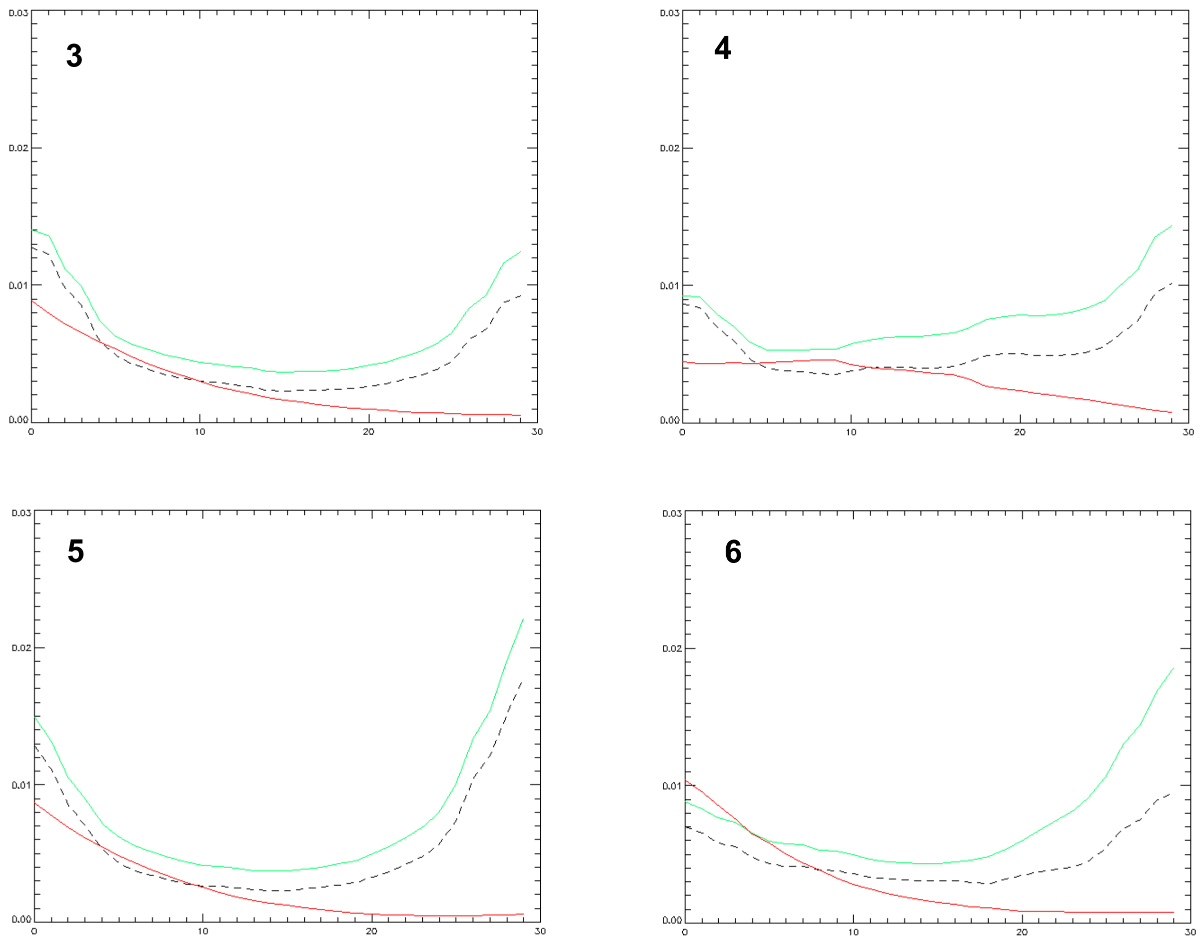




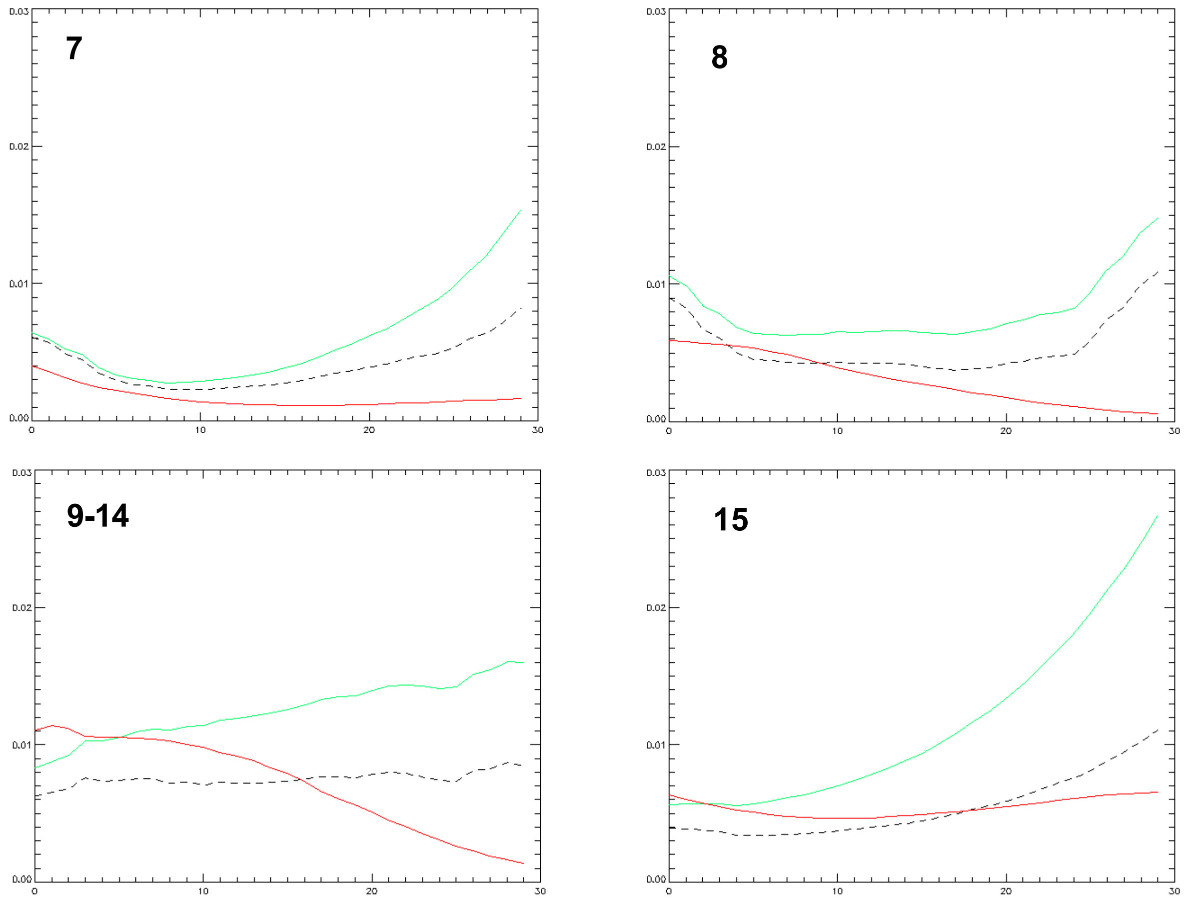
Dotted line: fc
Green line: fc+fsc
Red line: fss

MICROWAVE SCAN BIAS

Efficiencies: Ch. 3-6



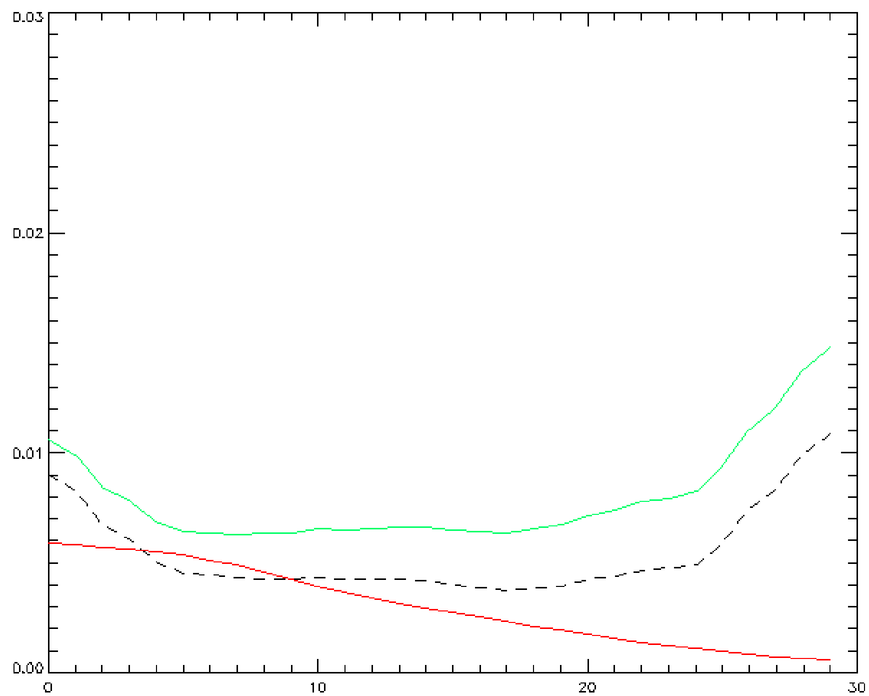
Efficiencies: Ch. 7-15



Reference: AMSU Ch. 8

Why channel 8?

- No surface effects
- Relatively low variability in radiometric field
- "Truth" is relatively well known

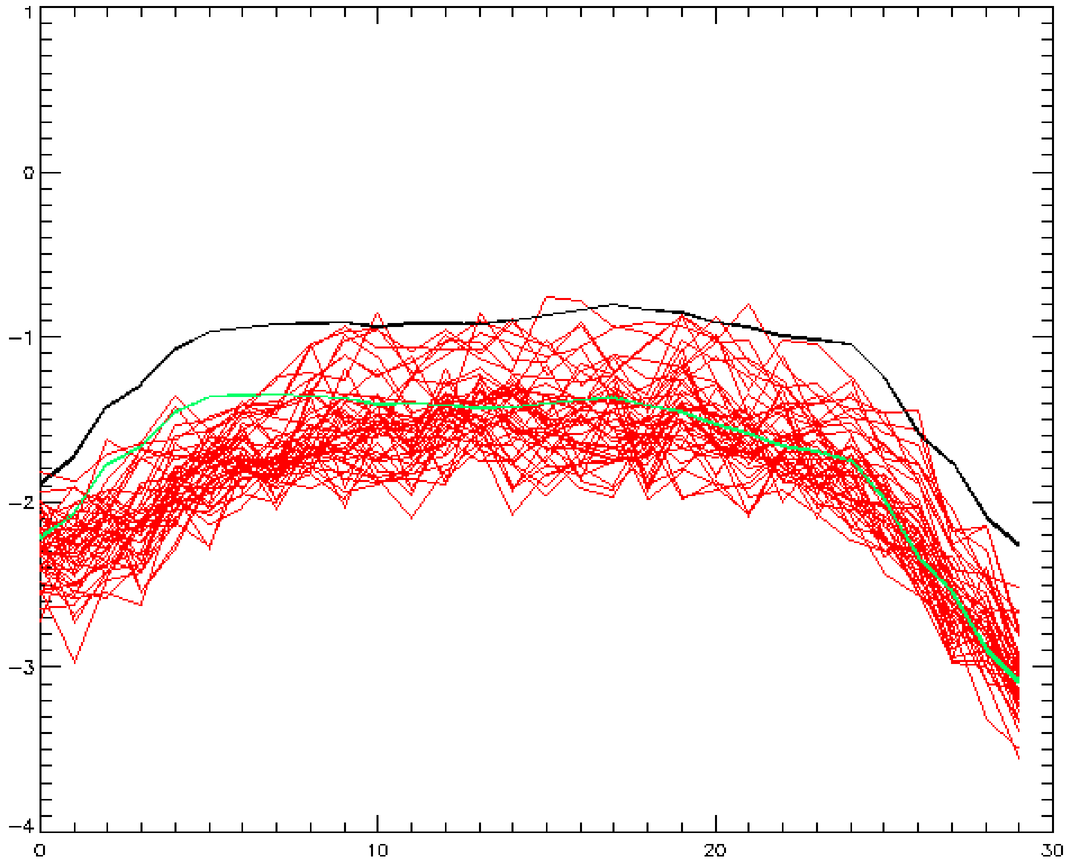


Bias Comparisons - Ch. 8

Red:
Obs-Calc

Black:
-fc•Tb

Green:
-(fc+fsc)•Tb



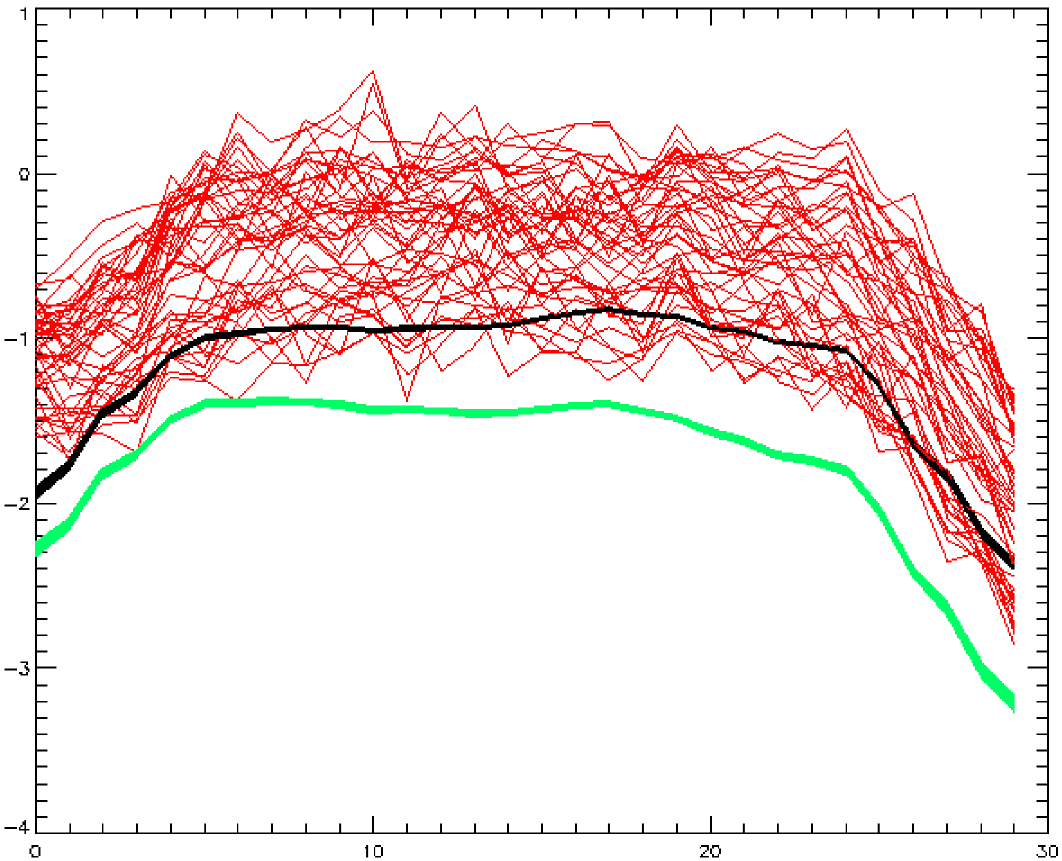
Focus Day 3, Granule 002 (9°S Desc)

Bias Comparisons - Ch. 8

Red:
Obs-Calc

Black:
-fc•Tb

Green:
-(fc+fsc)•Tb



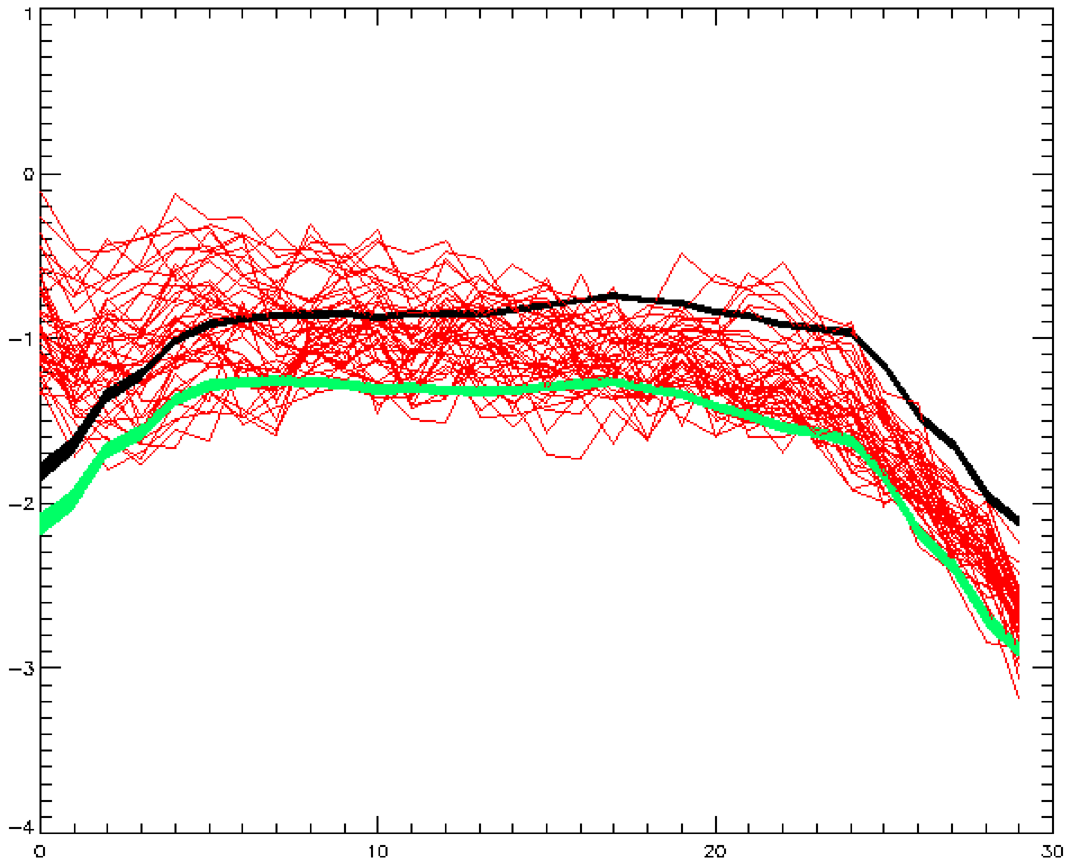
Focus Day 3, Granule 004 (52°S Desc)

Bias Comparisons - Ch. 8

Red:
Obs-Calc

Black:
-fc•Tb

Green:
-(fc+fsc)•Tb



Focus Day 3, Granule 006 (80°S Asc)

Bias Comparisons - Ch. 8

Red:

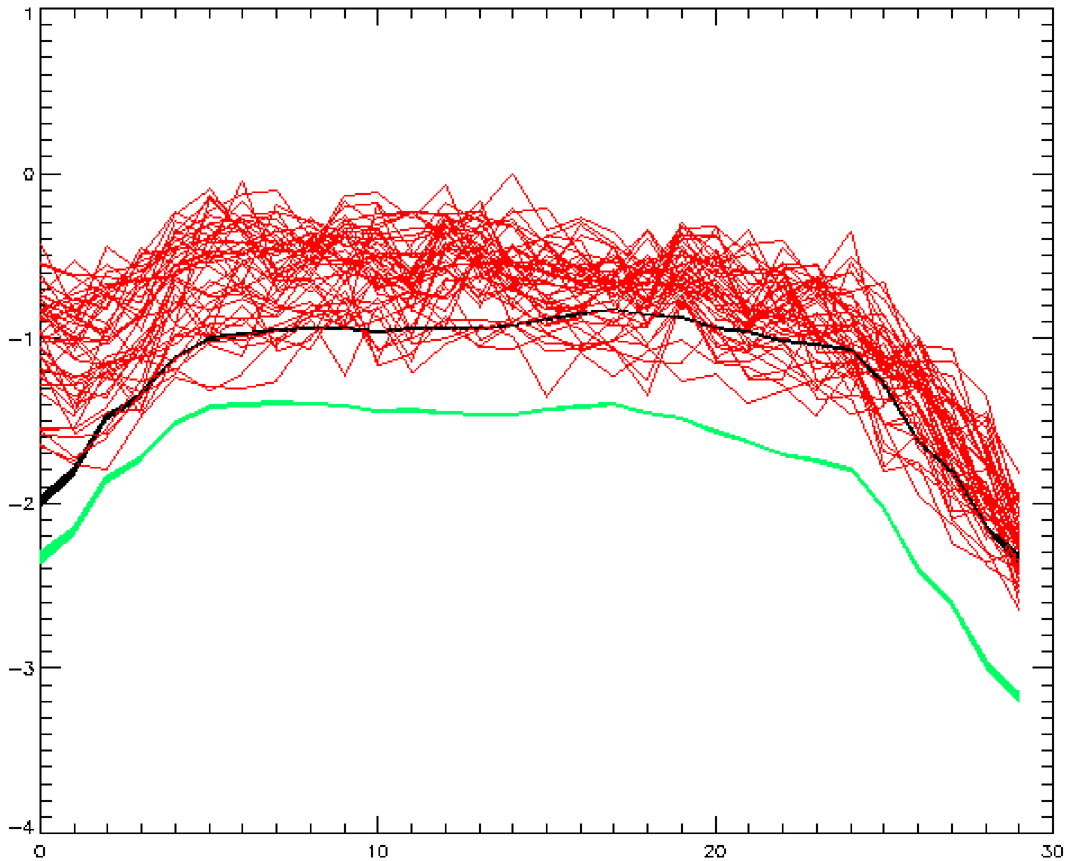
Obs-Calc

Black:

-fc•Tb

Green:

-(fc+fsc)•Tb



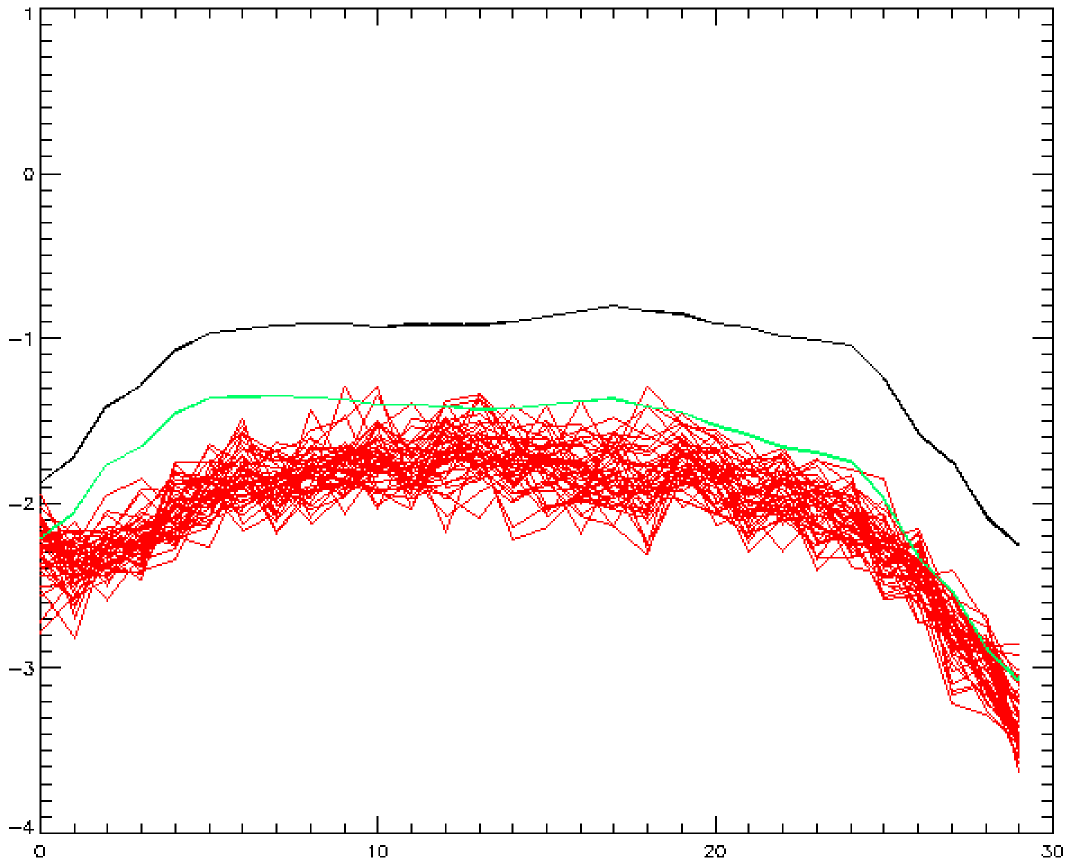
Focus Day 3, Granule 008 (40°S Asc)

Bias Comparisons - Ch. 8

Red:
Obs-Calc

Black:
-fc•Tb

Green:
-(fc+fsc)•Tb



Focus Day 3, Granule 010 (4°N Asc)

Bias Comparisons - Ch. 8

Red:

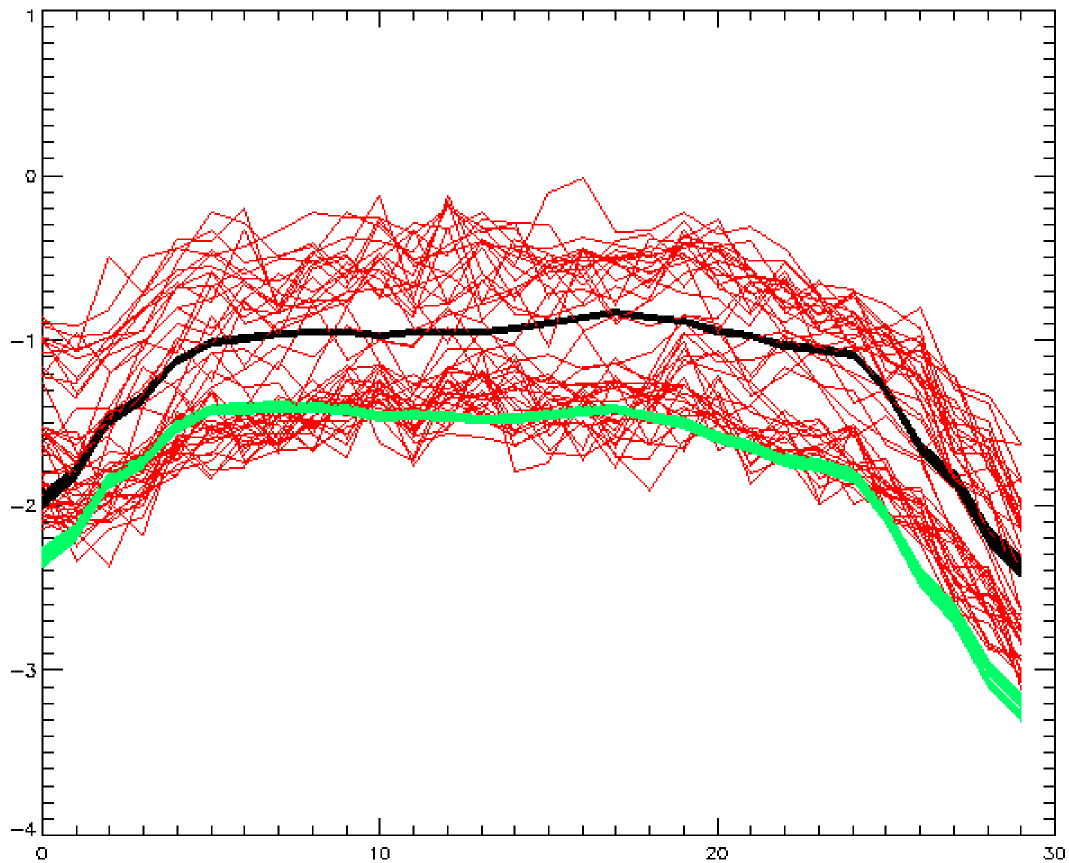
Obs-Calc

Black:

-fc•Tb

Green:

-(fc+fsc)•Tb



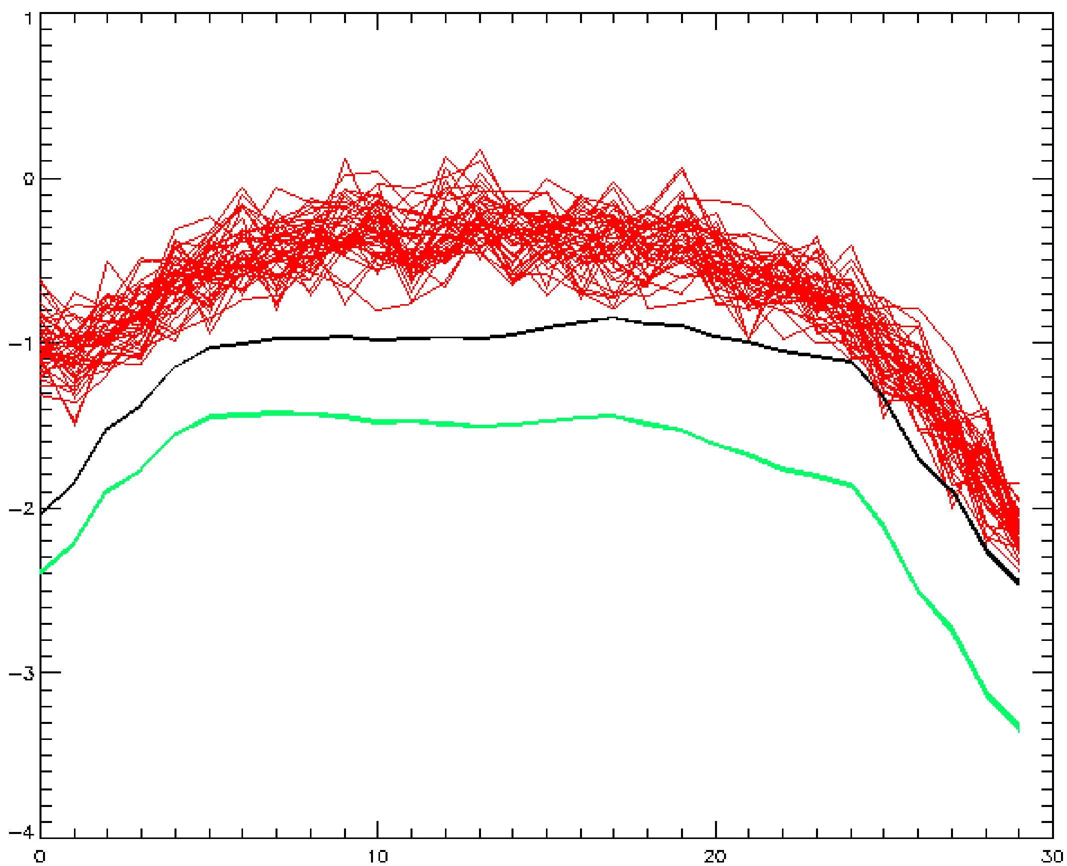
Focus Day 3, Granule 012 (47°N Asc)

Bias Comparisons - Ch. 8

Red:
Obs-Calc

Black:
-fc•Tb

Green:
-(fc+fsc)•Tb



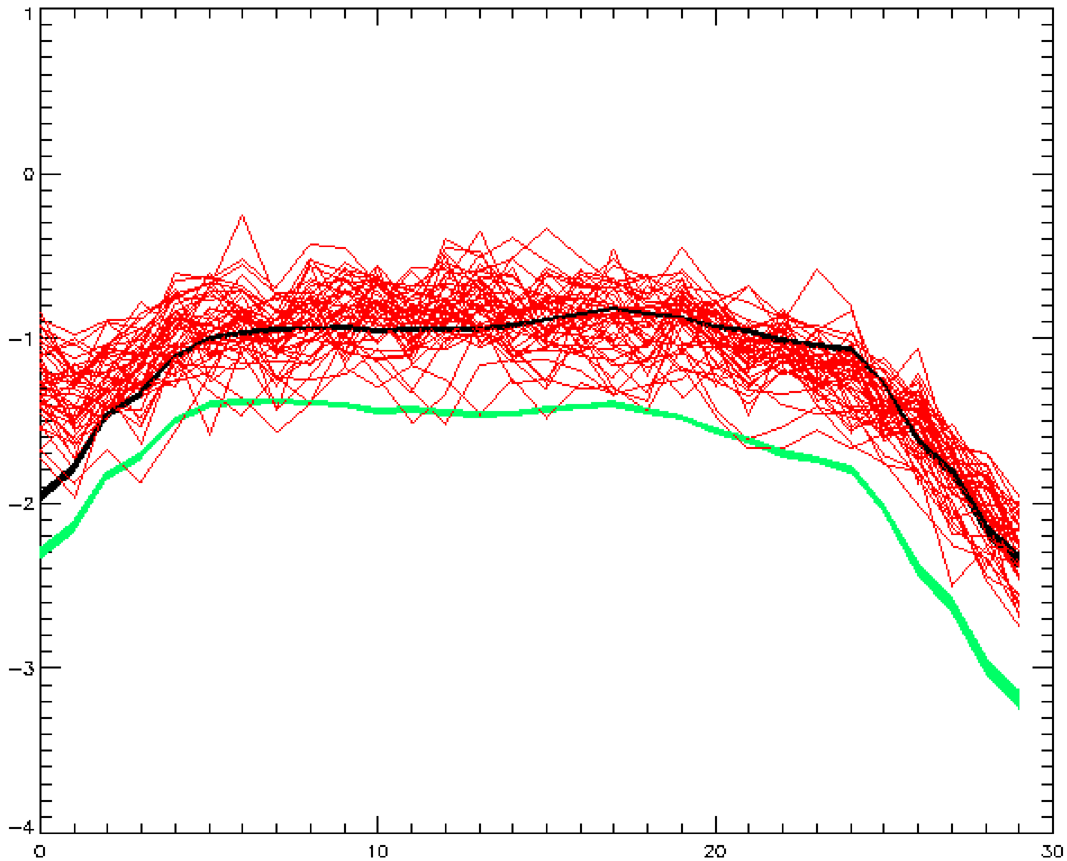
Focus Day 3, Granule 014 (82°N A/Desc)

Bias Comparisons - Ch. 8

Red:
Obs-Calc

Black:
-fc•Tb

Green:
-(fc+fsc)•Tb



Focus Day 3, Granule 016 (45°N Desc)

Bias Comparisons - Ch. 8

Red:

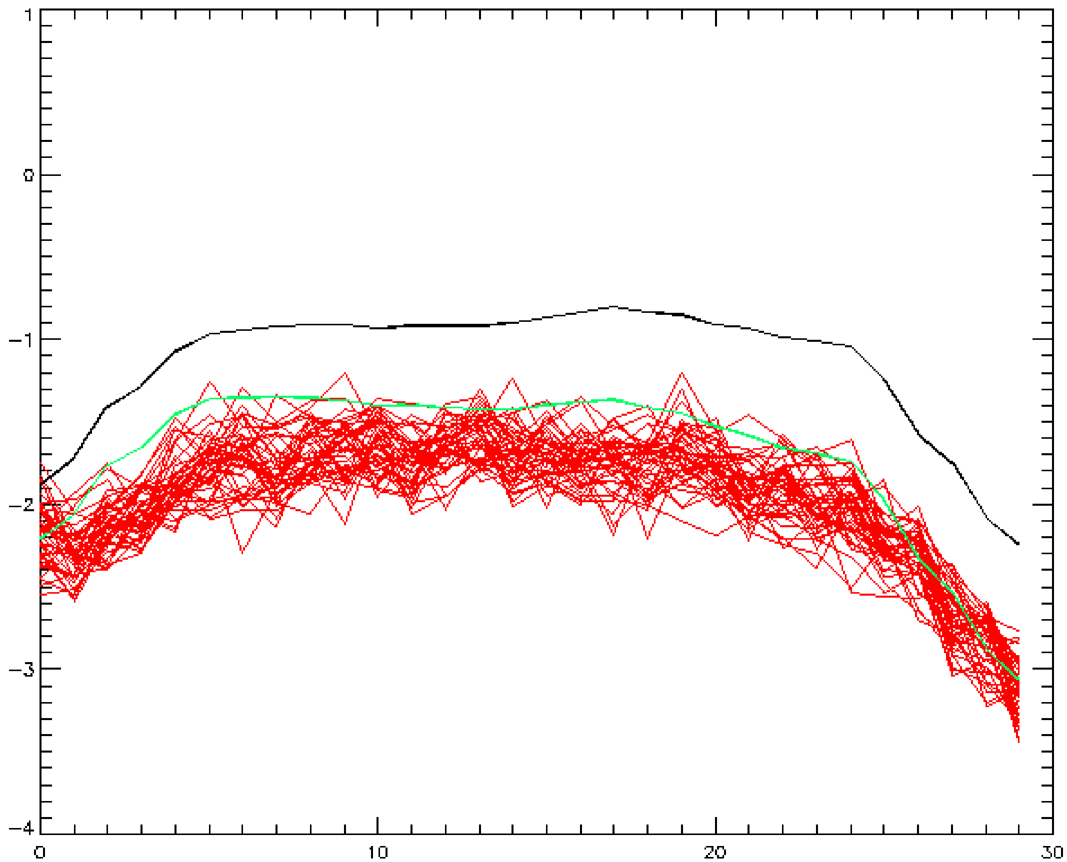
Obs-Calc

Black:

-fc•Tb

Green:

-(fc+fsc)•Tb



Focus Day 3, Granule 018 (1°N Desc)

Implementation Strategy

For L1b

- Implement baseline algorithm
- Determine f-tables
- Determine optimal S/C effective reflectivity (η)
- Test against model data

For L2

- Install switch to select Ta or Tb
- Match with tuning selection

Tuning

- If sidelobe correction is good: skip MW tuning
- If only fairly good: recompute MW tuning coefficients
- If poor: use current MW tuning

What's Next?

Radiometric benchmark

- Identify best "truth"
- Use to baseline correction method

Spacecraft environment

- Determine exact space-view solid angles
- Classify reflection angles & determine solid angles
  - Space
  - Earth
  - Sun

Baseline bias corrections

- Static approach (no scene dependence)

Future improvements

- Dynamic corrections
- Include possible solar reflection